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must have been many hundreds of these arrows in one single spheroid. Perhaps an oblate spheroid is not the best description of one of these masses. They resemble more a long capsule used in pharmacy with rather sharper ends, or the cigar-shaped balloon of an airship.

In looking for the cause of the discharge I suggested to Mr. Howard that it might be due to the contraction of the cell walls, due either to pressure of the cover glass or to drying. Mr. Howard suggested, and it is a very plausible reason, that it might be osmotic pressure due to the presence of certain mineral substances in the mother liquor. He proposes to test this theory experimentally by making a salt solution for mounting, to imitate, if possible, that within the bomb and thus to exclude osmotic pressure. Presumably, when left in the tissues of the plant the crystals are not discharged; at least, in the preparation which was under observation no free crystals were found until the bomb began to discharge the missiles; as the plant would grow older, however, and the osmotic conditions change, or the cell walls begin to dry, the discharges would begin to take place in the tissues of the plant. These bombs are bundles of crystals and are, of course, exceedingly small, and most of them would doubtless escape rupture during mastication, but a sufficient amount of them would discharge their arrows to account for the pricking sensations attending the mastication of this material.

Mr. Safford, who, while connected with the navy, spent some time among the Polynesians and made a study of the foods in common use, says that this plant is one of the principal food staples of the Polynesians and other Pacific islanders, who eat both the starchy rootstock, either baked or made into paste, and the young leaves which taste not unlike asparagus.

If the plant is not thoroughly cooked its acrid qualities remain in some degree. If thoroughly cooked they are destroyed. It is interesting to note that in cases where the leaves are chewed, either fresh or dried, the stinging sensation is not perceived until a

few moments afterward, and in many cases it is not until the taro root has been eaten that the prickling sensation in the lining of the mouth and throat shows that it has not been thoroughly cooked.

Alocasia indica, a plant closely allied to the taro plant, is so acrid that the Pacific islanders resort to it only in cases of great scarcity of food. The disagreeable effects caused by these plants seem to be confined to the temporary prickling sensation of the mouth and throat. They are undoubtedly nutritious and are held in high esteem by the natives. The acrid principle in the manioc or cassava is at least partly due to the presence of hydrocyanic acid, and this is removed by cooking. It will be interesting to see if any of this poisonous acid is also found in the taro and *Alocasia indica*.

In the case of an Indian turnip lately examined by Mr. Howard, the capsules were found to be somewhat smaller and the crystals larger and shorter than those described. A drop of the sap of the taro, which was shown under the microscope to contain no crystals, did not produce a burning sensation when placed in the mouth. On the contrary, a drop of the juice of the Indian turnip which carried free crystals was quite active in producing the characteristic symptoms. These facts are additional evidence to support the theory at first mentioned.

While not yet fully established, there is presumptive evidence that the pricking and burning sensation experienced in masticating materials of this kind is mostly of mechanical origin.

H. W. WILEY.

THE SEMINAR METHOD IN NATURAL SCIENCES, ESPECIALLY IN ZOOLOGY.

ANY one who has watched, for a number of years, the announcements of the lectures at German universities, will have noticed that the so-called 'Seminar-Übungen,' 'Colloquia,' or 'Besprechungen,' and 'Wissenschaftlichen Gesellschaften' have been extended more and more, and now take often an important place among the courses offered by a department.

The desire of reaching the student better

or, more properly, of making a more lasting impression on his mind than is possible through the mere words of lectures was, of course, felt everywhere. Instead of being merely receptive, taking in lectures, and comparing them, at best, perhaps with some books, the student was to be put face to face with the problem, to be forced to be reproductive, and thus to be led to become productive.

The strong sympathy for the perfect liberty of the university student throughout Germany discriminated against any attempt at introducing school methods into the university. The natural sciences, of course, had developed their demonstration and laboratory methods. The other sciences, which are grouped together as mental sciences (the German 'Geisteswissenschaften'), then tried also to introduce practical studies. Thus the seminar was developed and has gained in favor ever since. To-day we find 'Seminarübungen' offered in the different branches of theological studies, jurisprudence, history, philology, philosophy, etc.

The word 'seminar,' as it is used at the universities to-day, means, in the first place, a room provided with tables for the students and containing the department library, especially the periodicals, models, charts and other study collections. The students become members of the seminar by paying a small 'contribution.' They receive a key to the seminar rooms, a table and the right of access to, and use of, all the books and apparatus of the institution. Each seminar has a janitor to keep things in order, and is open from 8 A.M. to 9 P.M. (for members only, of course). The students spend hours between lectures there, study, write their theses, etc. One of the finest and best equipped seminars of which I ever was a member is the geographical seminar of Professor Ratzel at Leipzig. It consists of four rooms; one is the study of the professor, one the study of his assistant, one is a large room which contains a very fine department library and the tables for the students, and in the fourth large, hall-like room all the numerous charts and maps, models and instruments are kept and may be used on special large

tables. The fact that all but this last room open on an inner court of the university buildings shuts out the noise of the street, and the entire wing, being constructed to accommodate nothing but seminars on all its floors, is out of reach of the buzz of the students going to and coming from their lectures.

Besides the institution itself, the word seminar means also the 'colloquia' (or 'Besprechungen') and practical courses which are given in the institution and which are also called 'Seminarübungen' or simply 'Übungen.'

The term 'Gesellschaft,' as used by certain professors, means similar work, but on the whole it corresponds more to what we call zoological club or journal club in America.

The chief advantage of all these courses is that they bring the student in closer contact with the professor. From my own experience I know how much benefit may be derived from this method. While studying over there I was fortunate enough to be admitted, for a number of semesters, to the seminar conducted by the professor of history of art (Professor Schmarsow, of Leipzig). Although these studies were out of my line, I gained so much there, and got such an insight into the methods and ways of thinking of the representatives of the mental sciences, that I have always been extremely thankful for this chance.

Quite recently seminars and seminarübungen have also been offered in the natural sciences, more especially in zoology and botany, at some of the German universities. The mental sciences, which have found so many of our methods useful for their purposes, render thus, as it were, their thanks and offer us a method which they have developed and which we might accept, perhaps, with some advantage.

The 'Practica' and 'Praktischen Übungen' in natural sciences do not concern us here, they are simply laboratory courses independent of, or, better, separated from, the lectures. In many, perhaps most, cases the laboratory methods for the first years of study are decidedly better in this country. There are better instruments and apparatus at hand,

better laboratory and library facilities, more and better material to work with, and more personal instruction is given here than in Germany. The foreign methods—this may, perhaps, be said in their favor—make students more independent, because there are no strict directions to be followed, no note-books to be compiled. The professor gives you the animal, tells you the literature, and leaves you. You have to find out all about the creature yourself, and when he comes back you have to demonstrate to him what you have found. If that is not enough, he simply tells you that you have to keep on and he does not allow you to pass on to anything else until you have found and seen and drawn, yourself, everything that you can be expected to find. This method, of course, would not work with large classes. It can be used over there because the classes in zoology, botany and so on are always small and, besides, the students are more mature when they enter the university. Each professor has his individual laboratory method, which is just as good as anybody else's and which he does not care to publish. The general courses are always given by the head professor, because he is expected to have done so much special work that he is able to generalize. Thus he develops his methods from his special studies and carries them out, or has them carried out by his assistants. The younger 'docents,' on the other hand, give the advanced and special courses. They begin with their own specialties, widening their programs gradually, and thus develop special methods in their laboratory courses in their turn.

Where the classes are larger, and especially in the beginners' courses, the methods are often stricter and more school-like. In chemistry, physics, histology, etc., the methods are similar to those used in this country.

Let us see now what we may expect from a seminar in zoology, and in how many different ways it may be conducted.

I. There is, first, the simple method of reading a book with the students. This may be used as an introduction for beginners. Let us take, for instance, Darwin's 'Origin of

Species.' The students read a chapter at home; at the seminar, the chapter will be discussed and questions asked. The animals mentioned by Darwin will be exhibited as specimens or, at least, in good pictures. In connection with these animals a great many questions will come up, and the instructor may ask a member to look up some special literature and report the next time. Of course the instructor has his plan, which he follows, and in harmony with which he directs all the discussions. Here and there he will have to interpret and show that certain views can not be held any longer, or that some authority, perhaps himself, does not agree with Darwin, and why. Thus the students are given several points of view on the subject and led to independent thinking.

In this way, without school-like recitations, the whole book will be gone through. While, in a course of lectures, the students will get the general idea of evolution, the seminar will show them how such an eminent investigator as Darwin worked and reasoned, and will give them a lot of detailed knowledge, and many inspiring thoughts for their own work besides.

II. Another seminar would be, for instance, 'Darwin, His Life and Work.' The instructor gives an outline of Darwin's life; each member takes one book or certain chapters, reads them and prepares a report for the meeting. Discussions, explanations and demonstrations follow. If the class is small, all of the numerous books can not be read by the members, and the instructor will have to pick out certain books or chapters which seem most important or interesting, and to give short reviews of the others himself.

There are a great many important books and pamphlets about which a student of zoology ought to know something and which he can not possibly read all by himself, especially if they be written in a foreign language. More than one book in German or French can not be expected from a student per semester or per year, but when each member of the seminar reads one book, something can be accomplished for the mutual benefit. The instructor gives the necessary explanations,

shows specimens, or at least pictures, charts and diagrams, performs experiments, if necessary, and directs the discussion.

III. The instructor prepares a list of books or papers which all relate to the same subject, and which he wishes to discuss with his students. He announces, say, a seminar on Darwinism, and either asks the members to report on some books of Darwin's, Wallace's, Haeckel's, Romanes's, Weismann's, etc., or gives them some of the modern pamphlets dealing with evolution, heredity, variation, etc., for instance, Weismann's 'Germinal Selection,' Götze's 'Heredity and Adaptation,' Pfeffer's 'Transformation of Species,' some of Karl Pearson's papers, Cunningham-Weldon's controversy, some of Davenport's papers, etc.

IV. The instructor announces a seminar, say, on evolution. He makes out a list of topics relating to this special subject in such a way that they all together will more or less exhaust it. Such a list would be, for instance: Classification of organisms before and after Darwin. Geological and geographical distribution of plants and animals. Australia. Lamarck, Darwin, Wallace. Fertilization. Heredity. Variation. Species. Anthropoid apes. Pithecanthropus and the Engis, Spy and Neanderthal, Mentone and Cro-magnon skeletons. La Madelaine, Hallstadt, La Tène. Lake-dwellings, ancient and modern. Human races. Each member chooses one topic and makes himself acquainted with the main literature, prepares demonstrations and experiments, procures pictures and diagrams and works out a little lecture to be given before the seminar.

It is also a good idea to have these lectures written in the form of little essays which circulate among the members of the seminar after the lectures have been delivered and are, with their remarks on the margin, finally handed in to the instructor. In a later session the latter returns them and gives his criticisms both of the paper and the annotations.

V. In the same way, of course, a number of unconnected topics may be chosen. The instructor may want to have certain subjects brought up upon which the general interest

happens to be focused, or he may have discovered certain deficiencies in the studies of his students which they would be thus obliged to make up. The same method will enable him also to complement, as it were, his lectures and laboratory courses by treating certain topics a little more fully than he can afford in his regular course.

VI. So far the teaching or imparting of knowledge has been in the foreground; but still another idea can be accepted as the leading principle: thinking, which leads to research. In other words, all the steps may be gone through which have led to some important discovery, or the history of a problem may be followed up to its latest aspects. Here, of course, the original papers will have to be used to a much larger extent, and especially all the pros and cons will have to be brought out. We may take, for instance, all the different steps which finally have led to the discovery of the cycles of the parasites of malaria. (Laveran, Golgi, Labbé, MacCallum, Ross, Grassi, Ziemann, Koch, Grassi and others.) Or, taking fertilization, we might have: The old spermatists and ovulists, Schwann's work on the cells, Leuckart's article on reproduction; Darwin, Weismann; Flemming, Van Beneden, Fol, Carnoy; Bütschli, O. Hertwig, Conklin, Mark, Wilson; Rückert, Häcker; Meves; Boveri; Loeb, Morgan, Wilson; Maupas and R. Hertwig; Calkins.

VII. The method can also be used in laboratory studies, each member making a certain preparation, constructing a certain apparatus, making a diagram or chart, etc. In this way two birds, or three, might be killed with one stone; the member in charge is obliged to study and acquire a certain skill and certain methods to do his part as well as possible; the other members get the benefit of the demonstration, and the laboratory finally acquires for its collection some dissection, microscopic preparation, some piece of apparatus, a chart, some lantern-slides, etc.

VIII. A plan may be adopted which amounts to cooperation. In this way a résumé of a certain question may be given, for instance, a paper on the present aspect of

the problem of gastrulation may be prepared and published. Each member takes one group, such as the different types of fishes, amphibia, reptiles and so on, goes over the literature and works out his account. The whole thing is then put together, added to and got ready for publication by the instructor.

IX. For the sake of completeness I wish to mention here the so-called zoological clubs or research clubs, where each member gives a piece of his own research, and the journal clubs. In the latter, each member takes one or a number of journals and gives a report of all the papers which have been published therein, which seem of a more general interest, or the papers are assigned to the members, or each member selects a specialty and reports in his turn on all the new papers in this line.

The advantages of the seminar method, it seems to me, are the following : (1) we are more able to give our students an idea of the many-sidedness of a modern science. A young student, after having heard the usual lectures and done his laboratory work, may be ready to believe that there are some more animals which he did not study and that some things and courses may be given which could not be offered, or he could not take; but on the whole he is apt to believe that, having done what was required of him, he knows now about what can be known on the subject in question. A seminar may have the not very pleasant but useful task of showing him how little he knows; that is to say, it can give the students an idea of the different points of view from which we may look at the very things which they have studied, the different ways in which we may combine them in order to find our way to a deeper knowledge, to gain a new truth. There is not always time and opportunity to discuss a question or attack a problem from several sides in a lecture; we can at best allude to that; and in the laboratory the main object ought always to be the most careful and exact observation of a few forms. In fact, perhaps, nothing but established facts or accepted theories and hypotheses ought to be brought up in the lectures, in the laboratory nothing but points which can be demonstrated or

actually studied; the seminar is the place to give new ideas, to open new ways of looking at things, new connections and associations, to discuss uncertain points with their pros and cons, and to oblige the students to form an opinion of their own. In a seminar on Darwinism, for instance, we must offer and discuss, not only the points brought up by Nägeli, Eimer, Wolff, Dreyer, Götte, Cunningham, etc., but we must also see what Fleischmann has to say, and must let our students find his weak points.

(2) It seems to me that we often give, and have to give, certain things in our lectures which ought not to be given there. While I strongly believe that a careful study of anatomy or morphology is still and, after all, the only basis of all our further studies, be they physiological, psychological, bionomical and ecological or what else, it might, perhaps, be better to give in our lectures, aided by demonstrations, charts, models, lantern slides, etc., only the general outlines, the fundamental laws, certain views, certain points of the life history, habits, etc., and to leave details for a seminar. It is wonderful to develop before an audience the primitive forms of the embryo with the aid of models, clay and cloths of different colors, but when it comes to the details of the development of the vessels, muscles and the skeleton, the interest decreases equally with the student and with the teacher. In osteology the general features and arrangements of the bones in one animal, in a group or in the entire series of vertebrates, may profitably be explained in lectures; but the processes and their muscular attachments, the foramina and their passing nerves and vessels, and the details of the bones themselves, the peculiar twist, for instance, of femur and humerus, or of the ribs, are a rather dry subject for the hearer and unsatisfactory to lecture on for the instructor. What can not be covered by regular laboratory work could be treated in a seminar.

Especially helpful does the seminar appear in systematic zoology. Lectures on systematic zoology must always seem more or less unsatisfactory, even when supported by much demonstration material, because there are neces-

sarily too many names and too many, and often too fine, distinctive characters. In a seminar one group after another can be taken up. Each member studies one group, familiarizes himself with the characteristics, data, life histories, etc., and gives his demonstration. In a beginners' seminar the main groups may thus be treated; in an advanced seminar a small group may be studied more completely, and the members will have an opportunity to familiarize themselves with the main literature on the group, etc.

(3) A seminar can give the student an opportunity to see and compare more material than is possible in the laboratory course, and to see it better than is possible in a lecture or in the few minutes just before and after the lecture. The knowledge and faculty of observation gained by previous laboratory work enables the student to get a great deal out of the demonstration of comparatively much material which passes through his hands in a seminar. A student may have had, say a course in the dissection of an animal, the frog or the cat, for instance, and he may also have taken a course in comparative anatomy, and dissected a number of types such as *Amphioxus*, *Petromyzon*, a teleost, an amphibian, a reptile, a bird and a mammal. Then in a seminar it may seem desirable to study the different groups of fishes or amphibia more carefully. Each member makes a preparation of one system, or of all the systems of one animal, and gives his talk and demonstration on it. (Some of the better dissections may then be added to the museum.) Some skillful member may even be trusted with a dissection of a cecilian, or the instructor may do that himself. Or the sexual organs, the nervous system, may be taken and studied in the seminar by means of demonstrations, microscopic slides and talks prepared by the individual members. Such a series for the sexual organs would be: *Petromyzon*, *Myxine* and *Bdellostoma*; *Amia*, *Lepidosteus* and *Acipenser*; Teleosts: *Perca*, *Salmo* or *Esox* for the male, *Perca*, *Esox* and *Salmo* for the female, *Serranus*, *Embiotocus*; *Protopterus* and *Ceratodus*; *Scyllium*, *Mustela laevis*, *Raja*, *Chimæra*; *Necturus*, *Cryptobranchus*, *Diemyc-*

tilis and *Triton*, *Amblystoma*, *Plethodon*, *Rana*, *Bufo*; cecilian; snake, turtle, lizard, crocodile; bird; *Echidna* and *Ornithorhynchus*, marsupial, rabbit, cat, bat, monkey, man.

(4) Each member may work his studies into a little written composition which afterwards circulates among all the other members, who may add remarks and ask questions, and is finally handed in to the instructor. This work, it seems to me, is much more valuable to the students than keeping note-books. As we all know, note-books are a very doubtful means of education. They do not prove that the student has mastered the subject, for we have often seen students coming together and one of them dictating what the others put down with little individual changes. In other cases, the temptation of copying from books is too great. Under these circumstances, it seems an enormous waste of time for the student to say in his imperfect way what others have said ten times better, more clearly and correctly, and what he ought to read, or to have read, along with his studies, just as well as for the instructor to spend his time in correcting them, which he ought to spend in doing original work. The seminar obliges the student to work a subject up, making himself thoroughly familiar with it, and then present it in a way which, while it is not original research, certainly means an individual representation, and, as such, is an important step towards independent work.

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BOTANICAL NOTES.

STUDIES OF WATER MOLDS.

DR. BRADLEY M. DAVIS, of the University of Chicago, has just issued a quarto pamphlet of thirty-two pages, accompanied by two large plates devoted to the oogenesis of certain species of water molds (*Saprolegnia*). The paper appears as one of the Decennial Publications of the University of Chicago, and is well worthy of appearing in this notable series. The treatment is modern, and Dr. Davis is quite inclined to cut across some of the views which have fastened themselves